Possible implications of hemlock woolly adelgid on forest composition and structure in southeastern Ohio hemlock riparian forests

Katherine L. Martin and P. Charles Goebel

School of Environment & Natural Resources, The Ohio State University

Abstract

Hemlock woolly adelgid (HWA) is an invasive, exotic insect causing widespread mortality in eastern hemlock (*Tsuga* canadensis (L.) Carr) forests of the eastern United States. Eastern hemlock is thought to be a foundation species, regulating local ecosystem structure and function (e.g., microclimate, nutrient cycling). Prior to any possible invasions by HWA, we are sampling the vegetation composition and structure of hemlock forests of the unglaciated Allegheny Plateau region of Ohio. This data will provide a baseline for planning and prevention, which may be particularly valuable to a region with a significant tourism and recreation investment in hemlock-dominated ravine systems. Initial analyses indicate that hemlock forest ecosystems in southeastern Ohio may respond to large-scale disturbance associated with HWA differently than models developed for the northeastern United States. In southeast Ohio, eastern hemlock is associated with short, steep slopes or cliffs and does not seem to be limited by aspect. Hemlock is particularly dominant at lower slope positions adjacent to streambeds, where few other woody species are found in either the overstory or sapling layers. Unlike New England and some areas of the southern Appalachians, sweet birch is not a significant forest component in the overstory or sapling layers. Rather, species such as red maple and American beech (*Fagus grandifolia* Ehrh.) present in the sapling layer may be more likely to replace hemlock if HWA reaches these forest stands.

Introduction

Eastern hemlock

- Occurs in riparian and cove forests in central and southern Appalachians, including Ohio
- Creates unique habit
  - Damp, shady with dampened seasonal extremes
  - Slowly decaying, acidic litter, slower nutrient cycling
  - Provides for unique suite of fish, invertebrate and bird species (Snyder et al. 2002, Tingley et al 2002, Ross et al. 2003)

Hemlock woolly adelgid (HWA)

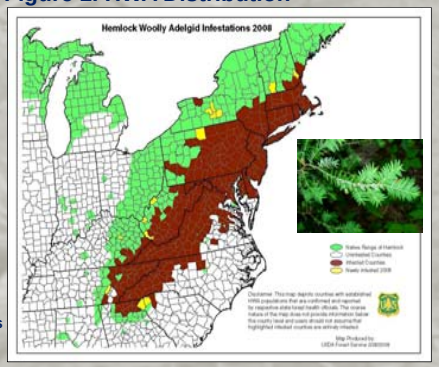
- Invasive pest introduced in Virginia in 1951 (nursery stock)
- Feeds on parenchyma cells of xylem rays leading to loss of needles, buds, branches and eventually mortality
- Feeds on all size and age classes
- Eastern hemlock shows no evidence of resistance.
- Life cycle, progression is occurring faster in south

Hemlock mortality

- Ohio is not yet invaded
- Bio-control research is ongoing, few results so far (Onken and Reardon 2008)
- Widespread mortality is occurring northern GA to southern Maine

Critical need for data prior to development of strategies for mitigation, restoration, and to refine future forest projections

Figure 1. HWA Distribution



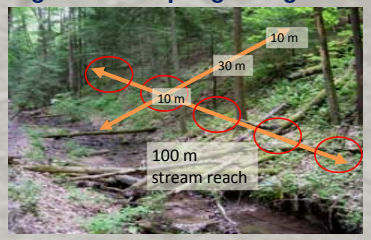
USDA Forest Service HWA distribution map for 2008. Inset picture of HWA on a hemlock branch. From approximately March- June, HWA is most easily identified by the white woolly masses.

Materials & Methods

At Lake Katharine State Nature Preserve in southeastern Ohio along a 100 m stream reach, we used:

- Transects 10, 30, and 50 m from the stream
- Five 100 m^2 circular plots every 15m along the transect (Fig. 2)
- Diameter at breast height (dbh) of all stems 2.5 cm dbh were recorded
- Slope percent, aspect, slope shape and slope position were measured

Figure 2. Sampling Design



Acknowledgments

Funding was provided by an OARDC graduate SEEDS grant, the OARDC Directors Office, and the College of Food, Agriculture, & Environmental Science. We are grateful to Stephen Rist and Keely Davidson-Bennett for valuable field assistance. David Hix provided site location advice.

References

Ellison, A. M., M. S. Banks, B. D. Clinton, E. A. Colburn, K. Elliott, C. R. Ford, D. R. Foster, B. D. Kloeppel, J. D. Knoepp, G. M. Lovett, J. Mohan, D. A. Orwig, and N. L. Rodenhouse. 2005. Loss of foundation species: consequences for the structure and dynamics of forested ecosystems. Frontiers in Ecology and the Environment 3:479-486.

McCune, B. and D. Keon. 2002. Equations for potential direct incident radiation and heat load. Journal of Vegetation Science 13: 603-606.

Onken, B. and R. Reardon (Editors). 2008. Proceedings of the Fourth Symposium on Hemlock Woolly Adelgid in the Eastern United States. USDA Forest Service

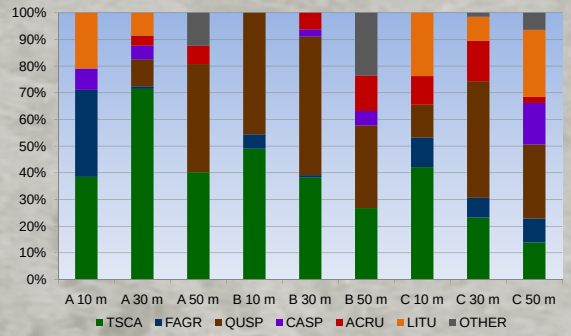
Ross, R.M., R.M. Bennett, C.D. Snyder, J.A. Young, D.R. Smith and D.P. Lemarie. 2003. Influence of eastern hemlock (Tsuga Canadensis L.) on fish community structure and function in headwater streams of the Delaware River basin. Ecology of Freshwater Fish 12:60-65.

Snyder C.D., J.A. Young and D. Smith. 2002. Influence of eastern hemlock (Tsuga canadensis) forests on aquatic invertebrate assemblages in headwater streams. Canadian Journal of Fisheries and Aquatic Science 59:262–75.

Tingley, M.W., D.A. Orwig, R. Field and G. Motzkin. 2002. Avian response to removal of a forest dominant: consequences of hemlock woolly adelgid infestations. Journal of Biogeography 29:1505-1516.

Results

Figure 3. Relative Basal Area of Overstory Species



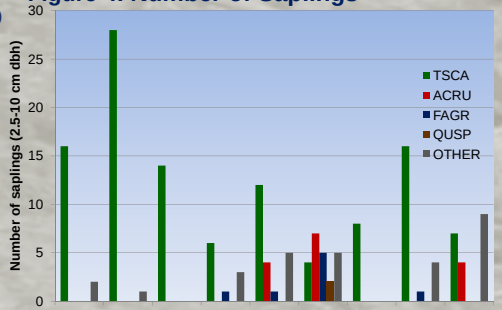
TSCA= Eastern Hemlock, FAGR= American Beech, QUSP= Quercus spp., CASP= Hickory spp., ACRU= Red Maple, LITU= Tulip Poplar, OTHER includes Black Gum, Flowering Dogwood, Sourwood, and Virginia Pine

Table 1. Species Richness & Diversity

Distance	Species Richness	Diversity (H')	Evenness	Hemlock basal area
10	4 ± 0.58[a]	1.19 ± 0.17	0.87 ± 0.04	50.0 ± 0.10%
30	6.33 ± 0.33[a,b]	1.30 ± 0.27	0.70 ± 0.14	38 ± 0.06%
50	8 ± 0.58[b]	1.86 ± 0.20	0.89 ± 0.07	26.4 ± 0.08%

Values are presented ± standard error. Letters represent values determined significantly different at =0.05 by a post hock comparison of a Kruskal-Wallis (non-parametric) test

Figure 4. Number of Saplings

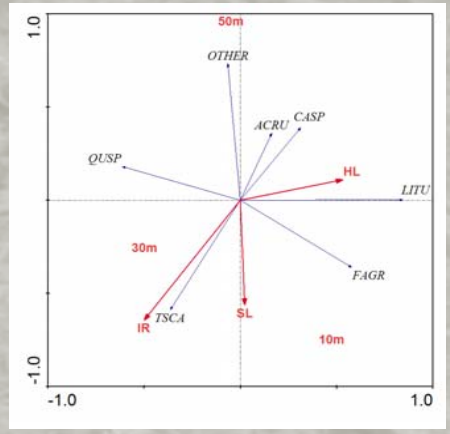


Abbreviations follow Fig. 3, except OTHER includes Black Gum, Umbrella Magnolia, Sourwood, and unidentified

Results Summary

- Hemlock is particularly abundant in riparian zones, within 30 m of the stream, where it comprises a large portion of the basal area (Fig 3, Fig. 5).
- Species richness is lower at positions adjacent to the stream and valley floor when compared to upslope positions (Table 1).
- Additional species contribute to greater species richness at positions further upslope away from streams (Fig. 3, Fig. 5, Table 1)
- Although species richness increases, this initial data indicates diversity and evenness do not differ between the three zones (Table 1)
- Hemlock is the dominant species in the sapling layer as well, with few other species. Some species within the sapling class (2.5-10 cm dbh) will not become canopy dominants, including dogwood, sourwood, and umbrella magnolia (Fig. 4).
- Redundancy analysis (RDA) indicates that hemlock is associated with steeper slopes at lower slope positions. American beech is also associate with lower slope positions. Oaks, hickories, and additional species such as black gum tend to occur on upper portions of the slope (Fig. 5).

Figure 5. RDA of Overstory Species & Environmental Variables



Species Abbreviations follow Fig. 3. 50m, 30m, and 10m refers to the distance from the stream, SL is slope percent, HL and IR are indices of heat load and incident radiation derived from aspect, slope percent, and latitude (McCune and Keon 2002)

Conclusions & Discussion

- Preliminary Conclusions
  - Both the overstory and sapling layers of steep ravines are dominated by hemlock, indicating that large-scale changes will occur should mass hemlock mortality occur.
  - Lower slope positions and steeper slopes are particularly dominated by hemlock, where few other species occur.
  - Unlike Massachusetts and Connecticut, we did not find sweet birch (*Betula lenta*) at Lake Katharine.
  - However, one ravine with evidence of recent logging (cables, stumps, logging road) did contain yellow birch (*B. alleghaniensis*), and tulip poplar, which raises the question whether birch will expand following disturbance.
- Ongoing study
  - Herbaceous species, including seedlings
  - Seed bank composition to identify possible sources of future recruitment
  - Particular emphasis on invasive species both in the understory and in the seed bank. One concern is that invasive species may be able to exploit canopy gaps following hemlock mortality
  - Soil characteristics including C, N, and pH
  - Functional characteristics including canopy composition and light availability, productivity, litter fall rate and chemistry, leaf litter diversity and decomposition rate, soil C:N ratios